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NUCLEAR CRITICALITY SAFETY EVALUATION
FOR THE HANDLING AND STAGING OF PRODUCT PURIFICATION CELL VESSELS

5A

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Nuclear Criticality Safety Evaluation for the Handling and Staging of Product Purification Cell Vessels

1.0 INTRODUCTION

This nuclear criticality safety evaluation (NCSE) provides the criticality and contingency analyses that have been performed to support the safe handling, removal, packaging, and storage of vessels 5D-6, 5E-7, 5C-2, 5C-6A, and 5C-6B located in the Product Purification Cell (PPC) of the Main Plant at the West Valley Demonstration Project (WVDP). The evaluation also provides a basis for the co-located storage of these vessels with plutonium product tanks 5D-5A and 5D-5B, also from the PPC.

2.0 DESCRIPTION

The PPC is located at the south end of the Main Plant immediately next to and east of Extraction Cell 3 at a plant elevation of 100 ft. A stainless steel liner covers the floor of the cell and extends 46 cm (18 in) up the walls; the remainder of the cell is carboline-coated concrete.

Equipment in the PPC was used by NFS to purify plutonium and uranium product streams and became contaminated from those activities. The portion of the PPC located north of an in-cell concrete divider wall was decontaminated from 1984 to 1986. The current project entails the removal of equipment remaining in the south portion of the cell and possible decontamination of cell surfaces. Legacy equipment in the PPC contains significant quantities of long-lived radionuclides. The equipment is to be removed to reduce the risks to workers, the public, and the environment. Equipment removal will be accomplished manually by personnel physically entering the cell.

The south portion of the PPC contains evaporators, ion-exchange columns, vessels, and piping that were originally used for the final purification and concentration of uranium nitrate and plutonium nitrate product streams. The main process influents originated in Extraction Cell 3: Tank 5D-1 for the plutonium (Pu) product stream and Column 4C-12A for the uranium (U) product stream. After processing in the PPC, the plutonium product stream was transferred to Product Packaging and Shipping, and the uranium product stream was transferred to the Uranium Product Cell. Other process streams were either routed for recovery/rework or to waste disposal.

2.1 Characteristics of PPC Equipment

This NCSE considers potential criticality issues associated with PPC equipment listed in Table 1.

Table 1. PPC Equipment Selected for NCSE

Identification	Description	Length (in)	Width (in) or Diameter (in)	Depth (in)
5D-5A	Pu Product Storage Tank No. 1	60-1/2	60-1/2	3

Table 1. PPC Equipment Selected for NCSE

Identification	Description	Length (in)	Width (in) or Diameter (in)	Depth (in)
5D-5B	Pu Product Storage Tank No. 2	60-1/2	60-1/2	3
5C-2	Pu Product Evaporator	85 (upper) 63 (lower)	5.563 (upper) 4.5 (lower)	n/a
5E-7	Pu Product Evaporator Condenser	54-3/8	4-1/2	n/a
5C-6A	Uranium Silica Gel Bed No. 1	132	10-3/4	n/a
5C-6B	Uranium Silica Gel Bed No. 2	132	10-3/4	n/a
5D-6	Pu Evaporator Condensate Tank	66	16	n/a

A limited number of historical radiation measurements have been reported for the PPC (Riethmiller 1981). In 1972, readings of up to 300 mR/hr were reported; readings of less than 100 mR/hr were reported in 1973. The measurement locations are unknown. Contamination levels both internal and external to equipment are also unknown. According to WVNSCO Memo FF:2002:0008, *Unreviewed Safety Question Determination - Product Purification Cell Clean-Up*, "The current residual inventory estimates have no direct analytical or measurement basis, but were derived from the limited radiation measurements and assumptions on the radiological distribution. In one case, a spent fuel radiological distribution was used, in another, a distribution derived from analysis of samples from the northern portion of the cell [was used]. Combined with the possibility of material hold-up in vessels...the existing estimates are expected to be neither accurate nor bounding."

Historical process information indicates that material hold-up in the form of a Pu "gel" or "polymer" that required manual removal occurred in ion exchange columns 5C-1A, 5C-1B, and 5C-1C (Riethmiller 1972). The Pu product tanks received flush solutions from upstream in the Pu purification process.

2.2 Summary of Cell Decontamination Activities

Characterization information will be collected on cell equipment prior to its removal, as noted in WVNSCO Memo FF:2002:0008. Several different methods will be utilized due to the breadth of information needed. These methods will be implemented in stages, and may include visual investigation, radiological measurement, tell-taling to detect residual liquids, sample collection, and laboratory analysis. Work will proceed from the bottom portion of the cell to the top.

Piping or equipment tell-tales will reveal the presence of liquid. If liquid is found, it will be sampled and analyzed. Solid samples will be collected from major equipment, from each type of pipe, and from the loose debris. Sampling operations may include removal of encrusted material from inside equipment, cutting coupons using mechanical cutting methods, and/or smear samples. Bulk solids contained within equipment will also be sampled and analyzed if necessary for future safe handling.

Piping or support structures still in place may require limited removal via mechanical cutting methods to access cell equipment for characterization work.

Equipment will be cut free using mechanical cutting methods only and sectioned as necessary to accommodate packaging into waste containers. Packaging criteria and waste container selection will be based on characterization results and the subsequent development of waste profiles, and on waste packaging-related Process Safety Requirements. The waste will either be packaged within the cell or will be transferred to the containment tent for placement into containers, then removed from the containment tent and transferred to on-site storage in the Lag Storage Facilities.

Heterogeneous loose debris is also present in the cell and requires removal for safe operations. The debris consists of surface-contaminated materials generated during previous work in the north side of PPC, and possibly some cut piping that has the potential to be internally contaminated.

Following removal of the equipment, an estimate will be made of residual radioactivity on cell surfaces and remaining support structures. If warranted to meet long-term performance goals, decontamination will be performed to reduce those radioactivity levels. Since contamination will have been fixed to the surfaces earlier in the project, decontamination would entail removal of at least the fixative coating(s). Spent decontamination media would be packaged and removed from the cell for eventual disposal or would be transferred to an on-site treatment facility.

3.0 REQUIREMENTS DOCUMENTATION

There are no requirements that are unique to this evaluation. This NCSE has been developed in accordance with the requirements of WVDP-162, *WVDP Nuclear Criticality Safety Program Manual*.

4.0 METHODOLOGY

4.1 Calculational Method

This NCSE uses published experimental data and analytical methods that have been validated by comparison with experimental data. The calculations that provide the basis for this NCSE were performed using two computer codes: KENO V.a and Monte Carlo n–Particle (MCNP) 4A. An overview of each code is provided in this section.

Criticality calculations for PPC equipment were performed using the KENO V.a module in the Standardized Computer Analyses for Licensing Evaluation (SCALE), Version 4.3, to estimate the neutron multiplication factor (k_{eff}). Verification and validation guidance and information related to KENO-V.a are provided in NUREG/CR-6483, *Guide to Verification and Validation of the SCALE-4 Criticality Safety Software*. The SCALE package is validated using published experimental data and a comparison is made between experimental values and calculated values to determine a bias. The experimental data used in the validation demonstrate that the computer code successfully applies to the models used in this evaluation.

The personal computer (PC) version of KENO V.a was run on an IBM Pentium IV, 1.3 GHz system, operating in a Windows 98 environment. Evaluated Nuclear Data File (ENDF) B-IV 27 energy group cross sections were used in all estimates of k_{eff}. A minimum value for k_{eff} (k_{min}) was established such that any KENO V.a calculation of k_{eff} equal to or greater than the minimum was considered critical. The k_{min} includes a bias established by correlating the results of critical benchmark experiments and also includes a margin of subcriticality. Based on an evaluation of the code bias, a subcritical limit of 0.93 was selected for use in this NCSE in assessing the criticality safety of normal operations.

Criticality calculations were also performed using MCNP 4A. MCNP is a general purpose, continuous energy, generalized geometry, time-dependent, coupled neutron-photon-electron Monte Carlo transport code system. MCNP treats an arbitrary three-dimensional configuration of materials in geometric cells bounded by first and second-degree surfaces and some special fourth-degree surfaces. For neutrons, all reactions in a particular cross-section evaluation are accounted for. MCNP is distributed by the Radiation Safety Information Computational Center (RSICC) located in Oak Ridge, Tennessee. Documentation for MCNP 4A is provided in LA-12625, *MCNP - A General Monte Carlo n-Particle Transport Code.*

MCNP uses continuous-energy nuclear and atomic data libraries from sources such as the ENDF system. Pointwise neutron cross section data are used and, for neutrons, all reactions given in a particular cross section evaluation are accounted for. Cross sections (whether continuous or discrete) based on ENDF/B-V evaluations are believed to be the best available to MCNP users at this time. Consequently, the ENDF/B-V cross section library was used for all evaluations referenced in this report.

The personal computer (PC) version of MCNP 4A was run on a Toshiba Pentium III, 333 MHz system, operating in a Windows 95 environment. *MCNP 4A Software Validation Plan and Report for Criticality Calculations* provides documentation of the validation activities that were performed to support the criticality calculations addressed in this NCSE. The bias and bias uncertainty related to the use of MCNP for evaluation of moderated and unmoderated systems containing plutonium are addressed in *MCNP 4A Software Validation Plan and Report for Criticality Calculations*. Through an evaluation of the code bias, a subcritical limit of 0.93 was selected for use in this NCSE in assessing the criticality safety of normal operations.

The criticality safety of PPC operations has been determined through the performance of a number of bounding analyses. These analyses evaluate a spectrum of conditions to envelope a broad range of potential decontamination operations. By design, these analyses range from a set of credible and anticipated conditions representing highly subcritical systems, to incredible configurations representing systems having the maximum reactivity for a given parameter or set of parameters such as geometry, enrichment, or moderation.

The intent of a criticality analysis is to demonstrate that a criticality concern has been satisfactorily evaluated and addressed through the imposition of appropriate controls. The analyses provided herein are considered to meet such an intent.

Results of calculations in support of this analysis were compared to published critical data to assess the reasonableness of the calculated values of k_{eff}. Referenced relevant critical data are cited below. Comparison may be made to cylinders containing plutonium solutions (5E-7 or 5C-2) and having inner diameters between 10.82 cm and 12.82 cm; to cylinders containing 5 wt% U-235-enriched uranium solutions (5C-6A or 5C-6B) and having an inner diameter of 26.035 cm; or to slabs containing plutonium solution (5D-5A and 5D-5B) and having a slab height of 6.35 cm.

Critical Data:

1. LA-10860-MS, Figure 24 gives a value of approximately 22 cm for the minimum critical infinite cylinder diameter for a heterogeneous water-reflected uranium solution having a U-235 enrichment of 5 wt%.

2. LA-10860-MS, Figure 24 gives a value of approximately 34 cm for the minimum critical infinite cylinder diameter for an homogenous unreflected uranium solution having a U-235 enrichment of 5 wt%.

3. LA-10860-MS, Figure 33 gives a value of approximately 15 cm for the minimum critical infinite cylinder diameter for a water-reflected cylinder containing $Pu(NO_3)_4$ solution at 200 g Pu/L with 1 N HNO_3 and 3.1% Pu-240 content.

4. LA-10860-MS, Figure 33 gives a value of approximately 22 cm for the minimum critical infinite cylinder diameter for an unreflected cylinder containing $Pu(NO_3)_4$ solution at 200 g Pu/L with 1 N HNO_3 and 3.1% Pu-240 content.

5. LA-10860-MS, Figure 34 gives an infinite slab thickness of 5.3 cm for a water-reflected slab containing $Pu(NO_3)_4$ solution at 200 g Pu/L with 1 N HNO_3 and 3.1% Pu-240 content.

6. LA-10860-MS, Figure 34 gives an infinite slab thickness of approximately 13 cm for an unreflected slab containing $Pu(NO_3)_4$ solution at 200 g Pu/L with 1 N HNO_3 and 3.1% Pu-240 content.

4.2 Description of Model

This section describes the features of the models that were used and states how the models bound the system under consideration.

Pu Product Evaporator:
Pu product evaporator 5C-2 is a titanium vessel that has been designed with a lower boiler section and an upper head section. The lower section of the evaporator is approximately 63" (160 cm) long and has a 4.5" (11.4 cm) outer diameter. The vessel thickness in this region is 0.237" (0.602 cm). The upper head region is approximately 85" (216 cm) long and has a 5.563" (14.13 cm) outer diameter with a wall thickness of 0.258" (0.655 cm) (reference Struthers Wells Corporation drawing 63-4-7745D1). Raschig rings were located in the center of the head region to act as a critically-safe mist eliminator, however, no credit has been taken in the analysis for the presence of these absorbers. The analysis assumes that the evaporator is cut at the transition between the narrower, lower portion and the wider upper portion to facilitate storage. The model further assumes that both the upper and lower sections of the evaporator are half full of an homogenous solution of $Pu(NO_3)_4$ containing Pu-239 at the maximum concentration processed by NFS (200 g Pu/L) and with no credit taken for Pu-240.

Pu Product Evaporator Storage Box:
The storage box for 5C-2 is constructed of 12 gauge (0.277 cm) carbon steel and has outer dimensions of 99-3/4" (253 cm) by 28-3/4" (73 cm) by 26-1/4" (66.7 cm). Note that these dimensions are for the actual container storage shell. The box has carbon steel risers that provide the box with an additional 4" (10 cm) clearance from the ground. (Reference Container Products Corporation drawing 11-3260-2-01.)

Pu Product Evaporator Condenser:
Pu product evaporator condenser 5E-7 is a stainless steel component that was used to condense overheads from 5C-2. The vessel has a uniform thickness of 0.120" (0.3048 cm) and is 54-3/8" (138 cm) in length. The condenser has a 4.5" (11.4 cm) outer diameter (reference Struthers Wells Corporation drawing 63-4-7752C1). The model assumes that 5E-7 is half full of an homogenous solution of $Pu(NO_3)_4$ containing Pu-239 at the maximum concentration processed by NFS (200 g Pu/L) and with no credit taken for Pu-240.

Pu Product Evaporator Condenser Storage Box:
The storage box for 5E-7 is constructed of 12 gauge (0.277 cm) carbon steel and has outer dimensions of 75-3/4" (192 cm) by 28-3/4" (73 cm) by 26-1/4" (66.7 cm). Note that these dimensions are for the actual container storage shell. The box has carbon steel risers that provide the box with an additional 4" (10 cm) clearance from the ground. (Reference Container Products Corporation drawing 11-3264-2-01.)

Uranium Silica Gel Beds:
Uranium silica gel beds 5C-6A and 5C-6B are identical in construction and were used for the final decontamination of uranium product solutions. The beds, which are constructed of 1/4" (0.635 cm) stainless steel, are 132" (335 cm) in length and have an outer diameter of 10-3/4" (27 cm) (reference Bechtel drawing 5B-C-2). The beds are assumed to be full of resin and have been assumed to be full of uranyl nitrate solution containing 5 wt% U-235.

Uranium Silica Gel Bed Storage Boxes:
The storage boxes for the gel beds are identical in construction and have dimensions of 150-3/4" (383 cm) by 32-3/4" (83 cm) by 30-1/4" (77 cm). Note that these dimensions are for the actual container storage shell. The boxes are constructed of 12 gauge (0.277 cm) carbon steel and have carbon steel risers that provide each box with an additional 4" (10 cm) clearance from the ground. (Reference Container Products Corporation drawing 11-3263-2-01.)

Product Tanks:
Tanks 5D-5A and 5D-5B are slab tanks that have been provided with boral plates to improve the criticality safety of the tanks. Tanks 5D-5A and 5D-5B are identical vessels having outer dimensions of 60-1/2" (154 cm) by 60-1/2" (154 cm) by 3" (7.6 cm). The tanks are constructed of 1/4" (0.635 cm) 304L stainless steel (Reference Bechtel drawing 5A-D-1). The models assume that the tanks are half full of an homogenous solution of $Pu(NO_3)_4$ containing Pu-239 at the maximum concentration processed by NFS (200 g Pu/L) and with no credit taken for Pu-240 or for the boral plates that were provided on the tanks to improve the criticality safety of the vessels.

Slab Tank Storage Boxes:
Storage boxes for tanks 5D-5A and 5D-5B are identical in construction, each box having outer dimensions of 85-3/4" (218 cm) by 85-3/4" (218 cm) by 17-1/4" (43.8 cm). The boxes are constructed of 12 gauge (0.277 cm) carbon steel and have carbon steel risers that provide each box with an additional 4" (10 cm) clearance from the ground. (Reference Container Products Corporation drawing 11-3261-2-01.)

Pu Evaporator Condensate Tank:
Tank 5D-6 is 66" (167.64 cm) in length by 16" (40.64 cm) in diameter and is constructed of 1/4" (0.635 cm) 304L stainless steel (reference Bechtel drawing 5B-D-5). The tank, which is the only vessel in the PPC-South that is not critically safe by design, was not intended to contain process solutions but was provided with Raschig rings to ensure criticality safety in the event of a process upset. No credit for the presence of the Raschig rings has been assumed in the analysis except to the extent that it serves as the basis for the assumption that the residual fissile material in the vessel is uniformly distributed throughout the vessel interior. Specifically, the model assumes that fissile material containing Pu-239 at the maximum concentration processed by NFS (200 g Pu/L) is evenly distributed throughout the interior of the vessel. The volume of $Pu(NO_3)_4$ solution in the tank is equal to that of half of the tank volume and an even distribution of the material throughout the vessel interior is accounted for by assuming half density solution (0.66675 g/cm^3) in the tank. The model further assumes that the presence of the rings results in a volume displacement of 20% in the liquid region, based on data provided in the NFS Safety Analysis Report; however, no credit is taken for boron in the Raschig rings or for Pu-240 in the product solution.

Pu Evaporator Condensate Tank Storage Box:
The storage box for 5D-6 is constructed of 12 gauge (0.277 cm) carbon steel and has outer dimensions of 84-3/4" (215 cm) by 43-3/4" (111 cm) by 41-1/4" (104.8 cm). Note that these dimensions are for the actual container storage shell. The box has carbon steel risers that provide the box with an additional 4" (10 cm) clearance from the ground and is lined with 1/2" plywood to protect container surfaces. (Reference Container Products Corporation drawing 11-3262-2-01.)

It was assumed that reflection for the storage unit is provided by 1 ft (30.48 cm) of concrete under the storage boxes during normal storage conditions. During accident or abnormal operations conditions it is assumed that additional reflection is provided by 4 ft (121.92 cm) of variable density water around the boxes. The reflection characteristics of concrete exceed those for a damp soil material and therefore were selected as the ground reflector in this model. No moderator is assumed to be in any of the boxes.

4.3 Dimensional Limits

Table 2 summarizes dimensions assumed for PPC equipment described above. The dimensions indicated are those used in the criticality analyses described in this NCSE.

Table 2. Dimensions of PPC Equipment

Component	Component Dimensions	Storage Box Dimensions
Evaporator 5C-2 (lower section)	Outer length: 63" (160 cm) Outer diameter: 4.5" (11.4 cm) Wall Thickness: 0.237" (0.602 cm)	Outer length: 99-3/4" (253 cm) Outer width: 28-3/4" (73 cm) Outer height: 26-1/4" (66.7 cm) Wall Thickness: 12 gauge (0.277 cm)
Evaporator 5C-2 (upper section)	Outer length: 85" (216 cm) Outer diameter: 5.563" (14.1 cm) Wall Thickness: 0.258" (0.655 cm)	Stored in the same box as the lower section
Evaporator Condenser 5E-7	Outer length: 54-3/8" (138 cm) Outer diameter: 4.5" (11.4 cm) Wall Thickness: 0.120" (0.305 cm)	Outer length: 75-3/4" (192 cm) Outer width: 28-3/4" (73 cm) Outer height: 26-1/4" (66.7 cm) Wall Thickness: 12 gauge (0277 cm)
Silica Gel Beds 5C-6A and 5C-6B	Outer length: 132" (335 cm) Outer diameter: 10-3/4" (27.3 cm) Wall Thickness: 1/4" (0.635 cm)	Outer length: 150-3/4" (383 cm) Outer width: 32-3/4" (83 cm) Outer height: 30-1/4" (76.8 cm) Wall Thickness: 12 gauge (0.277 cm)
Product Storage Tanks 5D-5A and 5D-5B	Outer Width: 60-1/2" (154 cm) Outer Height: 60" (154 cm) Outer Depth: 3" (7.6 cm) Wall Thickness: 1/4" (0.635 cm)	Outer length: 85-3/4" (218 cm) Outer width: 85-3/4" (218 cm) Outer height: 17-1/4" (43.8 cm) Wall Thickness: 12 gauge (0.277 cm)
Pu Evaporator Condensate Tank	Outer length: 66" (167 cm) Outer diameter: 16" (40.6 cm) Wall Thickness: 1/4" (0.635 cm)	Outer length: 84-3/4" (215 cm) Outer width: 43-3/4" (111 cm) Outer height: 41-1/4" (105 cm) Wall Thickness: 12 gauge (0.277 cm)

4.4 Assumptions

Parameters and considerations used in this NCSE are documented and accompanied by the rationale for the assumptions that were made. This documentation is sufficient to allow an independent review to be conducted.

Primary assumptions used in the development of the analytical models are:

- Fissile material in tanks 5D-6, 5C-2, 5E-7, 5D-5A, and 5D-5B is an homogenous solution of $Pu(NO_3)_4$ containing 200 g Pu/L.

- $Pu(NO_3)_4$ solution in tank 5D-6 is assumed to be uniformly distributed throughout the tank and is assumed to be half-density solution (0.66675 g/cm^3).

- Uranium silica gel beds 5C-6A and 5C-6B are full of an homogenous uranyl nitrate solution containing 5 wt% U-235.

- Vessels containing $Pu(NO_3)_4$ solution are half full.

- $Pu(NO_3)_4$ solution systems contain no Pu-240.

- Under normal operation conditions reflection of all boxes is provided only by the ground. Under accident and abnormal operation conditions reflection is also provided by variable density water on the top.

- Wastes packaged to meet the criteria of PSR-6 are the only other fissile material sources in the criticality control zone.

5.0 DISCUSSION OF CONTINGENCIES

A contingency is defined as "a possible but unlikely change in a condition/control important to the nuclear criticality safety of a fissionable material operation that would, if it occurred, reduce the number of barriers (either administrative or physical) that are intended to prevent an accidental nuclear criticality" (DOE-STD-3007-93). Parameters considered in the contingency analysis for PPC equipment are discussed in Section 5.1.

5.1 Parameter Discussion

The following parameters represent various means by which reactivity can be added to the system. A discussion of each will be made to demonstrate that the PPC equipment will be double contingent under all normal and credible accident conditions.

- **Geometry:** The most reactive storage configuration geometry has been considered for both normal and abnormal or accident conditions and has been found to be safe under all credible conditions of reflection and source term inventory. Geometry is not controlled.

- **Interaction:** Interaction of vessels containing significant quantities of fissile material may result in an unsafe condition. Although vessels removed from the PPC will be drained prior to handling, an assay of fissile material for the vessels will not be available prior to packaging. Consequently, controls will be imposed to limit the interaction of the stored vessels with other unanalyzed sources of fissile material. Analysis has shown that no controls will be required to limit interaction of staged boxes with each other or with containers of waste that have been packaged to meet the criteria of PSR-6. Interaction of the staged boxes with other fissile material waste forms has not been evaluated. Therefore, interaction is controlled.

- **Absorbers:** The only neutron absorbing material considered in this analysis is the stainless steel walls of the tanks. This material has only mild absorbing capability and was considered as part of the physical model of the system. Slab tanks 5D-5A and 5D-5B are provided with boral plates for neutron absorption; however, no credit has been taken for these plates in the analysis. Tank 5D-6 is believed to contain Raschig rings; however, no credit for the boron in these rings has been assumed. Absorbers are not controlled.

- **Concentration:** The analysis considered both the plutonium and uranium source terms to be plutonium nitrate and uranyl nitrate at their maximum respective product concentrations. Concentration is not controlled.

- **Moderation:** Moderation of packaged wastes is not anticipated under normal conditions or credible abnormal conditions. With the exception of the uranium silica gel beds, waste vessels will be drained prior to packaging and will be stored in sealed containers in a sheltered staging area. The source material itself is liquid and it is considered that this adequately bounds any potential moderation conditions. Moderation is not controlled.

- **Reflection:** Reflection is assumed to be provided by the ground and by operators in the vicinity of the waste boxes. Reflection by the ground is assumed to be concrete. No other significant sources of material reflection have been identified during normal storage operations. Reflection during accidents may result from the introduction of reduced-density water, as would be the case during fire fighting activities or roof failure due to snow loading. Reflection of the slab tank storage boxes under these conditions has been determined to not result in a critical configuration. Reflection is not controlled.

- **Mass:** Mass can be added to a waste box by placing multiple tanks in a single container. Vessels are proposed to be packaged with only one tank per waste box and no other fissile material in the box. Furthermore, the vessels will be drained of any residual liquid to minimize the amount of fissile material remaining in a box prior to packaging (although it is not anticipated that the uranium silica gel beds will be emptied of any residual resin). Vessels to be removed from the PPC have been designed with a fixed volume, as discussed below. These vessels are assumed to contain fissile materials having a maximum Pu concentration of 200g/L. Therefore, for a given vessel the maximum fissile mass is fixed. The mass of fissile material in a waste box will be controlled by placing only one vessel in a box. (The two sections of evaporator 5C-2 are assumed to be one vessel.) Mass is controlled.

- **Volume:** All vessels to be removed from the PPC have a fixed volume. For the analysis the maximum outer dimension of a vessels is used for the analysis, with the source region reduced only by the thickness of the vessel wall. No credit is taken for the volume displacement produced by vessel internal structures. Volume is not controlled.

- **Enrichment:** The design conditions are based on the assumption that the fissile material is fully enriched. The evaluated plutonium equipment is safe for high plutonium enrichments (96 w/o Pu-239). At this enrichment, the plutonium equipment is safe under all the accident scenarios postulated in this NCSE. The analysis also evaluates two components from the uranium processing system.

The source term assumed in the analysis is modeled as 5 wt% U-235 which represents the highest enriched uranium feed typically processed by NFS. Enrichment is not controlled.

6.0 EVALUATION AND RESULTS

Evaluations were performed for normal and abnormal or accident conditions. Configurations were selected to maximize reactivity under each of the evaluated conditions. The analytical approach involved evaluation of a case using the KENO criticality code system with an independent verification evaluation performed using MCNP. Results for all cases are presented in Appendix A.

6.1 Normal Conditions

Under normal conditions, the vessels will be staged individually in storage boxes on the ground in an area that has been designated as a criticality control zone to ensure that no other unanalyzed fissile material waste packages are brought in proximity to the containers. It is anticipated that the vessels will be laid directly into the storage boxes and will not be secured to the box. Each of the storage boxes is provided with 4" (10.16 cm) high risers that will provide a nominal clearance of the box from the ground. The vessels are assumed to be half full of $Pu(NO_3)_4$ containing 200 g Pu/L, except for vessels 5C-6A and 5C-6B, which are assumed to be completely full of 5 wt% U-235 -enriched $UO_2(NO_3)_2 \cdot 6H_2O$. Residual liquids in the plutonium tanks will be removed prior to placement in the storage box and therefore this assumption is believed to provide a maximum bound for any residual material still remaining in a tank.

To evaluate the most reactive normal storage configuration, a model was developed that assumes that each slab tank is located in a corner of it’s storage box in a way that it’s separation from other vessels containing fissile materials is minimized. In one case a slab tank is bordered immediately on two sides by evaporator 5C-2 and evaporator condenser 5E-7, and in the other case the tank is bordered on one side by tank 5D-6 and on the other side by the uranium silica gel beds 5C-6A and 5C-6B, which are assumed to be parallel to each other. The analysis of this case (Case NORM01) determined a $k_{eff} + 2\sigma$ of 0.8921. A verification analysis of this normal storage configuration was performed and the resulting $k_{eff} + 2\sigma$ for this case (Case 15ADUAE) was 0.84841. Although no analyses involving drums containing fissile materials at the PSR-6 limit were performed as part of the current analysis, previous analyses have indicated that these materials contribute negligibly to the reactivity of the system (ref. WVNS-NCSE-003) and are therefore considered safe for storage with the evaluated materials.

6.2 Abnormal Conditions

Abnormal or accident conditions may occur during the handling and staging of the vessels from the PPC. Actions required to ensure that criticality safety is maintained during credible abnormal and accident conditions are specified in Section 7.0. Conditions adversely affecting the reactivity of staged wastes include the introduction of additional reflector material, crushing of storage boxes, or combining multiple vessels in a single waste box.

Boxes containing PPC vessels may be stored in areas susceptible to external reflection beyond the reflection expected from the concrete surface of the staging area. Added reflection in the staging area may result from the use of water for fire fighting, in-leakage of rainwater due to roof leaks in the staging area, or due to roof collapse resulting from excessive snow loading. A parametric analysis was performed to determine the density of water corresponding to the optimum reflector. The result of this analysis, which is illustrated in Figure 1, below, indicates that the optimum reflector density is 0.3 g/cm^3. This density of water reflector was assumed to be present for all accident scenarios.

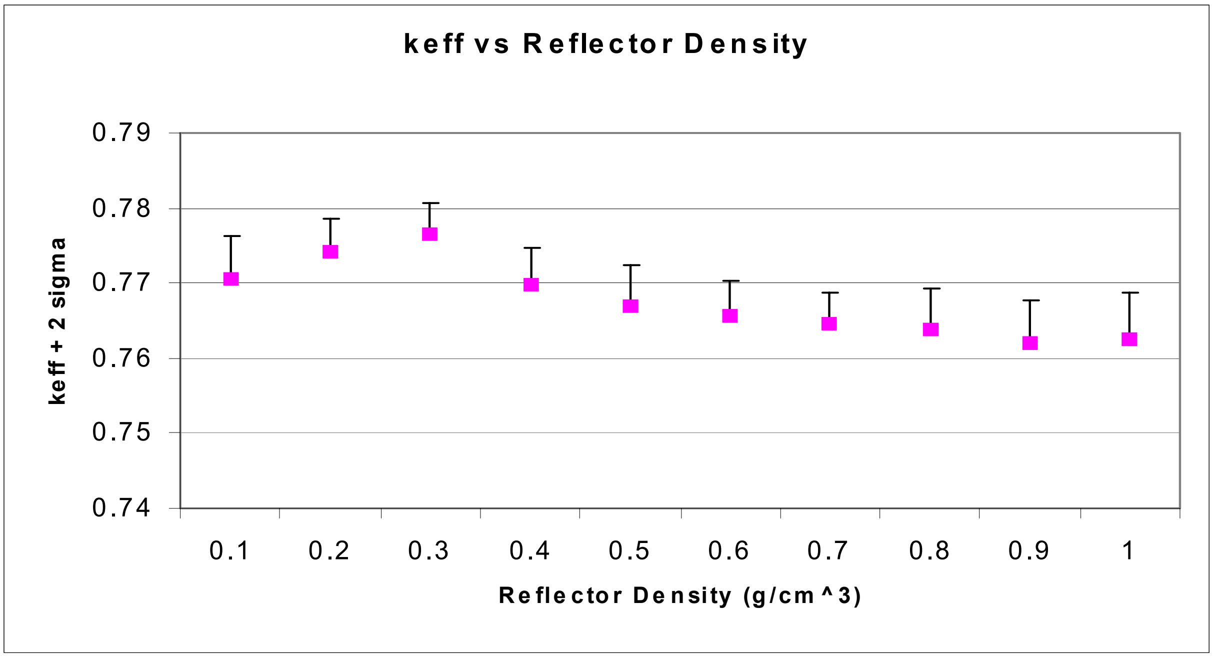

Figure 1 - Reflector Effectiveness vs. Density

A single bounding analysis was evaluated for the accident case. In the evaluated scenario, tanks 5D-5A and 5D-5B are stacked on top of each other with the tanks centered within their respective storage boxes. The box containing tank 5D-6 is assumed to be on top of the slab tank boxes and centered on the top slab tank box. The boxes containing tank 5E-7 and the two sections of 5C-2 are placed on top of the top slab tank storage box also and the vessels within the 5E-7/5C-2 storage boxes are placed such that the distance between these tanks and tank 5D-6 is minimized. Finally, the two boxes containing uranium silica gel beds 5C-6A and 5C-6B are assumed to be immediately adjacent to the boxes containing the slab tanks. The gel beds are located in their storage boxes in a way that minimizes their distance to the edge of the slab tanks. The entire configuration is then assumed to be reflected by 4' (101.6 cm) of optimum density water on the top and by concrete from below. The evaluated configuration is illustrated under the accident case presented in Attachment B. The calculated $k_{eff} + 2\sigma$ for this case (Case TOMB01) was 0.8857. This analysis was verified with MCNP (Case 15ADUAD) in which a $k_{eff} + 2\sigma$ of 0.8902 was calculated. The results of these calculations are tabulated in Appendix A.

6.2.1 Hazard Identification

6.2.1.1 Hazard Evaluation Technique

This section identifies the hazards assessment methodology used to evaluate process hazards. Table 3 in Section 6.2.1.2 displays the results of 'What If' scenarios that were used to identify various upsets that could possibly add reactivity to the system. There are a total of 7 cases, each of which is discussed in detail in Section 6.2.2, Criticality Hazard Analysis.

6.2.1.2 Hazards Identified

he following table was generated by considering various means by which reactivity can be added to the system and through discussions with process personnel on how various processes can fail.

Table 3. Hazard Identification for Handling and Staging of PPC Vessels

Case	What If	Hazard/ Consequence	Safeguard	Comment
1	Concentration exceeds the nominal expected.	Increases reactivity.	Tanks are assumed to contain $Pu(NO_3)_4$ or $UO_2(NO_3)_2$ solution at the max concentration processed by NFS	
2	Enrichment exceeds the nominal assumed.	Increases reactivity.	Pu-239 enrichment is greater than any actually processed by NFS. No Pu-240 assumed in the analyses. U-235 enrichment is assumed to be 5 wt%, which is max typically processed by NFS.	
3	Vessels become moderated during staging.	Increases reactivity.	Storage boxes will be sealed and provided with water-proof HEPA filters.	
4	Waste box becomes fully reflected by water on the outside.	Increases reactivity.	None.	Analysis has shown that staged waste boxes are safe under conditions of optimum external reflection.
5	An operator places an item containing fissile material next to waste box containing PPC vessel.	Increases reactivity.	Waste boxes will be stored in administrative control areas that will limit the interaction of the boxes with unanalyzed wastes.	Analysis has determined criticality safety of placement of PSR-6 waste containers around staged waste boxes.

Table 3. Hazard Identification for Handling and Staging of PPC Vessels

Case	What If	Hazard/ Consequence	Safeguard	Comment
6	Multiple vessels are combined in one waste box.	Increases reactivity.	Procedural requirements will specify that only one vessel be placed in a storage box. (The two sections of 5C-2 are assumed to be one vessel.)	
7	Vessels interact with other unanalyzed fissile materials during loadout.	Increases reactivity.	Cell decontamination sequence limits fissile material exposure during handling (bottom-up decontamination process).	Interaction with drums packaged to meet PSR-6 criteria determined to be safe.

6.2.2 Criticality Hazard Analysis

This section provides an analysis of each criticality hazard identified in Section 6.2.1.2.

Case 1: Concentration exceeds the nominal expected in a given vessel.

The maximum concentration processed by NFS based on operations records has been utilized in the analysis. The results are tabulated in Appendix A. Even if each vessel is half full at the maximum concentration and the system is fully reflected on the bottom by concrete and on the top by optimum density water, the system is subcritical ($k_{eff} + 2\sigma < 0.93$).

Case 2: Enrichment exceeds the nominal assumed.

Analysis shows that the system is subcritical even when product solutions at the maximum enrichments processed by NFS are used.

Case 3: Vessels become moderated during staging.

The tanks will be stored in lidded boxes that are fitted with filters that are resistant to water in-leakage. Due to radiation contamination concerns the tanks will be packaged immediately following detachment from in-cell supports and therefore moderation during the small interim period between detachment and placement in the storage box is not a concern. There is no credible means for flooding the staging area and water infiltration into the storage box due to roof leakage or fire fighting once the lid is in place is not credible.

Case 4: <u>The vessel becomes fully reflected by water on the outside.</u>

Reflection of a waste box by full density water would involve water levels in the storage area greater than three feet deep. Flooding to this extent in the storage area is not credible (as discussed in Section 6.2.3). Reflection of the storage boxes by reduced-density water is possible during fire-fighting in the staging/storage area, inleakage of rainwater through roof leaks, or following roof collapse due to excessive snow loading. Analyses have determined that the stored waste containers are safe even under conditions of optimum external reflection.

Case 5: <u>An operator places an item laden with fissile material from the staging area next to the vessel.</u>

Analyses have determined that placement of PSR-6 waste containers in proximity to the stored tanks is safe. Administrative controls will be used to ensure that fissile material wastes other than PSR-6 wastes are maintained at a safe distance by establishing a buffer region around the waste staging area.

Case 6: <u>Two slab tanks are inadvertently packaged in the same waste box.</u>

Analyses that have evaluated the double-batching of slab tanks in a single waste box is safe (ref. WVNS-NCSE-003). This case represents the bounding interaction case for two tanks combined in the same storage box

Case 7: <u>Tanks interact with other unanalyzed fissile materials during loadout.</u>

Vessel handling procedures assure that the tanks do not interact with other unanalyzed fissile materials. The cell decontamination sequence requires that cell equipment be removed in a bottom-up process. Constraints of cell geometry prohibit in-cell storage of potentially significant fissile material sources. Nevertheless, analysis has further demonstrated that packaged wastes may be safely stored in proximity to several containers of drums packaged to the limit of PSR-6 (ref. WVNS-NCSE-003).

6.2.3 Flooding Potential Due to Natural Phenomena

The likelihood of flooding the inside or outside of waste containers in storage that contain fissile material from the PPC is extremely small because (1) “the site’s topographic setting renders the likelihood of major flooding not credible, and local run-off and flooding is adequately accommodated by natural and man-made drainage systems in and around the WVDP,” as stated in WVNS-SAR-001, *Safety Analysis Report for Waste Processing and Support Activities*; (2) waste containers will not be stored in locations below grade, and (3) waste containers will be vented with a HEPA filter that can withstand at least 122 cm (48 in) water column without allowing water entry into a container (Nuclear Filter Technology Incorporated NucFil 013 filter with Gore-Tex, or equivalent).

Chapter 3 of WVNS-SAR-001 provides an extensive discussion of surface hydrology phenomena associated with the WVDP site and surrounding area that presents facts and analyses supporting the conclusion that major flooding is not considered credible. Section 3.4.2.1 of WVNS-SAR-001 states that, "Historical evidence and computer modeling indicate that flood conditions (including the probable maximum flood) will not result in stream flows overtopping their banks and flooding the plateau."

Under conditions of the probable maximum flood (PMF), it is observed in Section 3.4.3 of WVNS-SAR-001 that, "The lowest portion of the Main Plant is approximately 1,410 feet NGVD, whereas under PMF conditions, the nearest stream would rise to only 1347.2 feet NGVD." Per section 3.4.2.2 of the SAR, "In the case of the hypothetical PMF, which has a peak discharge nearly eight times that of the 100-year flood, it was demonstrated... that culvert headwaters would overtop Rock Springs Road and some part of the floodwaters would flow across the plant area. Based on the topography in the plant area, it is likely that some portions of the site would experience shallow flows of moderate velocity. Flows would recede quickly, however, since the ditches that drain the site have gradients of up to 5%."

Finally, regarding a probable maximum precipitation (PMP) event, Section 3.4.2.3 of WVNS-SAR-001 states that, "The 24-hour PMP for this watershed as supplied by the U.S. Weather Bureau is 24.9 inches. The effects of the PMP on site drainage systems would be overwhelming. Capacities of storm drain inlets at grade and in sumps would be exceeded. Ditches along open section roadways would overflow, flooding roadways and adjacent areas. None of the culverts within the watershed would be expected to prevent overtopping of its embankments, which raises the possibility of embankment failures. In the case of the 24-inch corrugated metal pipe (CMP) culvert beneath the railroad embankment along Frank's Creek...flow would be directed to the water supply reservoirs before the embankment elevation was exceeded. Failures of culvert embankments would not threaten any safety-related facilities in the plant area."

7.0 DESIGN FEATURES (PASSIVE AND ACTIVE) AND ADMINISTRATIVELY CONTROLLED LIMITS AND REQUIREMENTS

The criticality analysis has evaluated a normal storage configuration in which specific PPC vessels are stored individually in lidded waste boxes. Although the evaluation of parameters in section 5.1 indicates that mass is a controlled parameter, analyses associated with case 6 of section 6.2.2 have determined that the most reactive combination of vessels (i.e., 5D-5A and 5D-5B) may be safely stored in the same waste box. The mass parameter is controlled through the scope of the proposed activity (i.e., the packaging and staging of vessels 5D-6, 5C-2, 5E-7, 5C-6A and 5C-6B) and therefore no other controls for maintaining a safe mass are required.

Boxes containing the PPC vessels addressed by this NCSE shall be stored in a criticality control zone that has been established for the purpose of limiting interaction of the containers with other unanalyzed fissile material sources. Analyses have assessed PSR-6 wastes in proximity to vessels removed from the PPC and have concluded that this configuration is safe; however, storage of other fissile-bearing wastes in proximity to these wastes has not been analyzed. Consequently, while wastes packaged to meet the criteria of PSR-6 may be stored within the staging area containing the vessels removed from the PPC, a perimeter of 8 feet, as discussed in WVNS-SAR-001, must be maintained between these stored waste boxes and other sources of fissile material.

8.0 SUMMARY AND CONCLUSIONS

Product Purification Cell vessels 5D-6, 5C-2, 5E-7, 5C-6A and 5C-6B can be removed and stored in proximity to slab tanks 5D-5A and 5D-5B as well as PSR-6 wastes in a manner that ensures criticality safety. The analysis in this NCSE incorporates very conservative assumptions regarding the residual fissile inventory in the vessels. Prior to removal, vessels will be drained to minimize the potential for the release of highly radioactive liquid wastes. It is very conservative to assume that the vessels in the storage configuration are half full of product solution at the maximum concentrations processed by NFS.

Abnormal operations and accident conditions considered the extreme scenario in which the entire collection of waste storage boxes are accumulated in a central region; vessels within the storage boxes are configured to achieve maximum reactivity; the vessels are half full of plutonium solution at the maximum Pu concentration processed by NFS, or completely full of 5 wt% U-235 - enriched uranyl nitrate solution in the case of uranium silica gel beds; and the entire system is reflected by optimum density water. Even under these conditions, the maximum $k_{eff} + 2\sigma$ was found to be 0.8921, which is also subcritical by a wide margin.

It is therefore concluded that vessels 5D-6, 5C-2, 5E-7, 5C-6A and 5C-6B may be safely stored in the proposed storage configuration.

9.0 REFERENCES

American Nuclear Society. ANSI/ANS 8.1. *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*. 1983.

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APPENDIX A

TABULATED RESULTS

Table A-1. Results of Analysis for Normal Conditions

Description	k_{eff} + 2σ	
	KENO	MCNP
Each slab tank (5D-5A and 5D-5B) is located in a corner of it's storage box in a way that it's separation from other vessels containing fissile materials is minimized. Tank 5D-5A is bordered immediately on two sides by evaporator 5C-2 and evaporator condenser 5E-7, and tank 5D-5B is bordered on one side by tank 5D-6 and on the other side by the uranium silica gel beds 5C-6A and 5C-6B, which are arranged parallel to each other with column 5C-6A between tanks 5D-5A and 5C-6B. The system is reflected on the bottom by 1' of concrete.	0.8921 [NORM01]	0.84841 [15ADUAE]

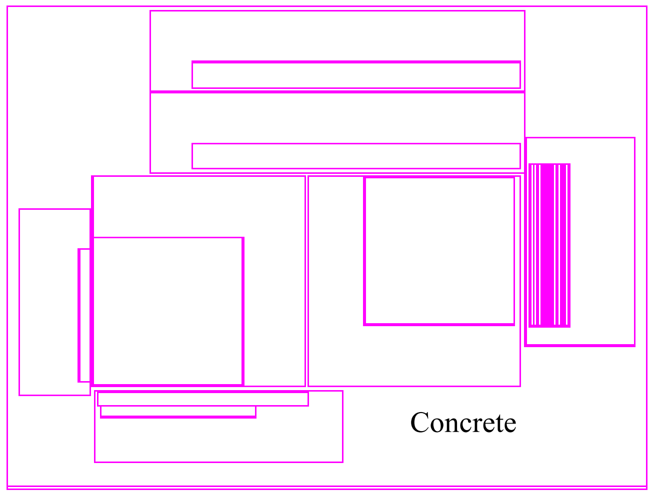
Table A-2. Results of Analysis for Accident Conditions

Description	k_{eff} + 2σ	
	KENO	MCNP
The entire collection of waste storage boxes are accumulated in a central region; vessels within the storage boxes are arranged to achieve maximum reactivity; the vessels are half full of plutonium solution at the maximum Pu concentration processed by NFS, or completely full of 5 wt% U-235 - enriched uranyl nitrate solution in the case of uranium silica gel beds; and the entire system is reflected by optimum density water.	0.8857 [TOMB1]	0.89020 [15ADUAD]

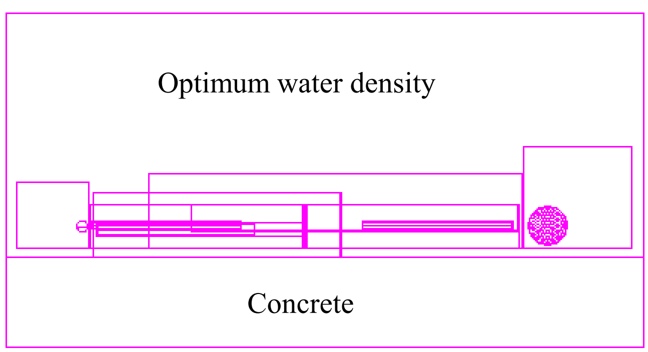
APPENDIX B

FIGURES

NORMAL CONDITION

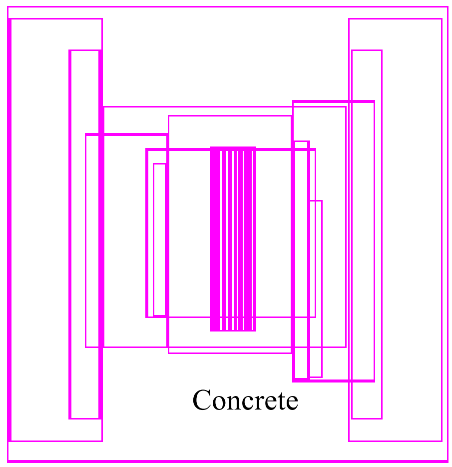


PLAN VIEW - 5C-6A and 5C-6B full; 5D-5A, 5D-5B, 5E-7, and 5C-2 half full; 5D-6 half density

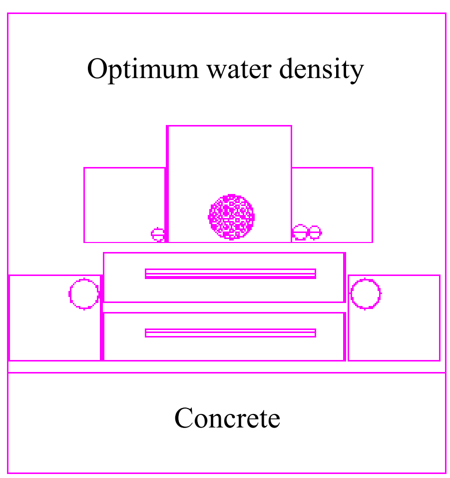


SECTION VIEW - 5C-6A and 5C-6B full; 5D-5A, 5D-5B, 5E-7, and 5C-2 half full; 5D-6 half density

ACCIDENT/ ABNORMAL CONDITION



PLAN VIEW - 5C-6A and 6B full; 5D-5A, 5D-5B, 5E-7, and 5C-2 half full; 5D-6 half density



SECTION VIEW - 5C-6A and 6B full; 5D-5A, 5D-5B, 5E-7, and 5C-2 half full; 5D-6 half density

APPENDIX C

INPUT LISTINGS

NORM01

```
=CSAS25   PARM=SIZE=250000
TWO SLAB TANKS, TWO SILICA GEL BEDS, EVAP, EVAP COND, EVAP COND TK-
NORM01
'HALF FULL SOURCE IN EACH TANK except FULL IN SILICA GEL COLUMNS
'SIDES AND TOP OF BOXES REFLECTED BY 3FT SNOW - .30 DENSITY
'BOTTOM REFLECTED BY 3FT CONCRETE
'.001 H2O INSIDE BOXES
27GROUPNDF4  INFHOMMEDIUM
SOLNPU(NO3)4 1 200 0 1. 293 94238 0.43 94239 96.14 94241 2.92 94242
0.51 END
SOLNPU(NO3)4 10 200 0 .5 293 94238 0.43 94239 96.14 94241 2.92 94242
0.51 END
SOLNUO2(NO3)2 8 350 0 1. 293 92235 5. 92238 95.  END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  2 1.0 END
SS304 3 1.0 END
H2O  4 0.001 END
REG-CONCRETE  5  1.0  END
H2O  6 0.3 END
'B-10  7 0 9.14626-4 END
'B-11  7 0 3.68149-3 END
O     7 0 4.49308-2 END
NA    7 0 2.39502-3 END
AL    7 0 4.97719-4 END
SI    7 0 1.80268-2 END
TI   9 1.0 END

END COMP
TWO SLAB TANKS, TWO SILICA GEL BEDS, EVAP, EVAP COND, EVAP COND TK-
NORM01
READ PARM NB8=400 GEN=120 NPG=6000 NSK=20
TBA=4 NUB=YES TME=1000 PLT=NO END PARM

READ GEOM

  COM="5D-5A & 5B"
  COM=" 2.50IN X 5FT X 5FT SLAB TANK - HALF FULL OF SOURCE"
UNIT 1
CUBOID   4  1 153.034   0.636   153.034   0.636   6.984  3.810
CUBOID   1  1 153.035   0.635   153.035   0.635   6.985   .635
CUBOID   3  1 153.670   0.  153.670   0.  7.62  0.

  COM="SUBSET OF ONE SLAB TANK BOX CONTAINING ONE UNIT 1 SLAB TANK"
UNIT 2
CUBOID   4  1 218.0819  0.2769  218.0819  0.2769  44.0919 0.2769
HOLE   1    64.   1. 19.53
CUBOID   3  1 218.3588 0.  218.3588 0.  44.3688 0.

  COM="SUBSET OF ONE SLAB TANK BOX CONTAINING ONE UNIT 1 SLAB TANK"
UNIT 3
CUBOID   4  1 218.0819  0.2769  218.0819  0.2769  44.0919 0.2769
HOLE   1    1. 58. 19.53
CUBOID   3  1 218.3588 0.  218.3588 0.  44.3688 0.

  COM=" 10.7532 CM DIA SPHERE FULL OF PU-239(96)NH - 55GAL DRUM"
'UNIT 40
'SPHERE   1  1  5.3766 ORIGIN  0.  0.  0.

  COM="1 7/16 OD X 15/16 ID PYREX PIPE"
UNIT 4
XCYLINDER  10 1 1.1906  167.0   0.00 ORIGIN  0. 0.
XCYLINDER   7 1 1.8256  167.0   0.00 ORIGIN  0. 0.

  COM="40.64CM OD X 167.64CM LG PU EVAP COND TANK FULL OF PU NITRATE"
UNIT 5
XCYLINDER  10 1 19.685 167.64  0.00 ORIGIN  0. 0.
HOLE 4 0 0 17.80
HOLE 4 0 0 12.00
HOLE 4 0 0 6.00
HOLE 4 0 0 0
HOLE 4 0 0 -6.00
HOLE 4 0 0 -12.00
HOLE 4 0 0 -17.80

HOLE 4 0 5.0 15.00
HOLE 4 0 5.0 9.00
HOLE 4 0 5.0 3
HOLE 4 0 5.0 -3
HOLE 4 0 5.0 -9.00
HOLE 4 0 5.0 -15.00

HOLE 4 0 -5.0 15.00
HOLE 4 0 -5.0 9.00
HOLE 4 0 -5.0 3.00
HOLE 4 0 -5.0 -3.00
HOLE 4 0 -5.0 -9.00
HOLE 4 0 -5.0 -15.00

HOLE 4 0 10. 12.00
HOLE 4 0 10. 6
HOLE 4 0 10. 0
HOLE 4 0 10. -6.00
HOLE 4 0 10. -12.00
HOLE 4 0 -10. 12.00
HOLE 4 0 -10. 6.00
HOLE 4 0 -10. 0.00
HOLE 4 0 -10. -6.00
HOLE 4 0 -10. -12.00

HOLE 4 0 15.0 9.00
HOLE 4 0 15.0 3
HOLE 4 0 15.0 -3
HOLE 4 0 15.0 -9.00

HOLE 4 0 -15.0 9.00
HOLE 4 0 -15.0 3
HOLE 4 0 -15.0 -3
HOLE 4 0 -15.0 -9.00

HOLE 4 0 17.6 0.00
HOLE 4 0 -17.6 0.00
XCYLINDER   3 1 20.32  167.64  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 5 - 5D-6"
UNIT 6
CUBOID   4  1  215.5419  0.2769 111.4019  0.2769    105.0519  0.2769
HOLE   5    28. 25. 23.
CUBOID   3  1   215.8188  0. 111.6788  0.   105.3288  0.

  COM="27.305 OD X 335.28 LG URANIUM SILICA GEL BED - 5C-6A"
UNIT 7
YCYLINDER    8 1 13.0175  335.28  0.00 ORIGIN  0. 0.
YCYLINDER  3 1 13.6525  335.28  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 7 - 5C-6A"
UNIT 8
CUBOID   4  1 83.4619  0.2769  383.1819  0.2769  77.1119  0.2769
HOLE   7   66. 43. 31.
CUBOID   3  1  83.7388  0.  383.4588  0.   77.3888  0.

  COM="27.305 OD X 335.28 LG URANIUM SILICA GEL BED - 5C-6B"
UNIT 16
YCYLINDER    8 1 13.0175  335.28  0.00 ORIGIN  0. 0.
YCYLINDER  3 1 13.6525  335.28  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 7 - 5C-6B"
UNIT 9
CUBOID   4  1  83.4619  0.2769 383.1819  0.2769   77.1119  0.2769
HOLE   16  66. 43. 31.
CUBOID   3  1  83.7388  0.  383.4588  0.  77.3888  0.

  COM="14.13CM OD X 215.9CM LG PU PROD EVAP  - LARGE END - TOP - 5C-2"
UNIT 11
YHEMICYL-Z   1 1 6.4097  215.9   0.00 ORIGIN  0. 0.
YCYLINDER   9 1 7.065  215.9   0.00 ORIGIN  0. 0.

  COM="11.43CM OD X 160.02CM LG PU PROD EVAP - SMALL END- BOTTOM- 5C-2"
UNIT 12
YHEMICYL-Z   1 1 5.11302  160.02  0.00 ORIGIN  0. 0.
YCYLINDER   9 1 5.7150  160.02  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 10 AND ONE UNIT 11 - 5C-2"
UNIT 13
CUBOID   4  1 73.3019  0.2769  253.6419  0.2769  67.2288  0.2769
HOLE   11  8. 3.  29.
HOLE   12  21. 5. 29.
CUBOID   3  1 73.5788  0.  253.9188 0.  67.2288  0.

  COM="11.43CM OD X 138.1125CM LG PU PROD EVAP CONDENSER - 5E-7"
UNIT 14
XHEMICYL-Z   1 1 5.4102  138.1125   0.00 ORIGIN  0. 0.
XCYLINDER   3 1 5.715  138.1125   0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 14 - 5E-7"
UNIT 15
CUBOID   4  1 192.6819  0.2769 73.3019  0.2769  66.9519  0.2769
HOLE   14  41. 67. 22.
CUBOID   3  1 192.9588  0.  73.5788  0.  67.2288  0.


  COM="SLAB OF CONCRETE 3FT X 13.56FT X 13.56FT"
UNIT 17
CUBOID   5  1 497.38  0.  659.38  5.  91.44  0.

  COM="BENCHMARK- START SOURCE SPHERE"
UNIT 10
SPHERE 2 1 1.6  ORIGIN 0. 0. 0.

  COM="COLLECTION OF ALL SUBSETS INTO GLOBAL"
GLOBAL
UNIT 18
CUBOID   6  1  324.941  -175.441   567.941  -86.441 251.66 -91.441
HOLE   2   0.  0. 10.16      COM="5D-5A"
HOLE   3   0. 221.2 10.16    COM="5D-5B"
HOLE   6   -40.  444.  10.16 COM="5D-6"
HOLE   8  -86. 60.  10.16.   COM="5C-6A"
HOLE   9  -170. 60.  10.16   COM="5C-6B"
HOLE   13  223. 3. 0.        COM="5C-2"
HOLE   15   35. -75. 10.16   COM="5E-7"
HOLE   17   -175.44  -91.44  -91.44  COM="CONCRETE"
'HOLE  10  156.  76.   32. COM="5D-5A"
'HOLE  10  76.  386.   32.  COM="5D-5B"
'HOLE  10   73.  469.   34.  COM="5D-6"
'HOLE  10  161.  -8.  30.5  COM="5E-7"
'HOLE  10  -104.  280.   30. COM="5C-6B"
```

```
'HOLE  10  -20.   280.   30. COM="5C-6A"
'HOLE  10  240.   120.  28.  COM="5C-2-LARGE-TOP"
'HOLE  10  254.   90.  28. COM="5C-2-SMALL-BOTTOM"


END GEOM
READ START NST=6
TFX=156. TFY=76. TFZ=32. LNU=750
TFX=76. TFY=386. TFZ=32. LNU=1500
TFX=73. TFY=469. TFZ=34. LNU=2250
TFX=161. TFY=-8. TFZ=30.5 LNU=3000
TFX=-104. TFY=280. TFZ=30. LNU=3750
TFX=-20. TFY=280. TFZ=30. LNU=4500
TFX=240. TFY=120.  TFZ=28. LNU=5250
TFX=254. TFY=90. TFZ=28. LNU=6000
END START
END DATA
END
```

15ADUAD

```
15ADUAD - PPC Tanks - Upper Level
c
c Cell cards
c
c --------------------------------------------------------------------
c Tank 5D-6:
10  66 -0.66675  -20                                     u=1  imp:n=1
11  68 -2.23      20 -21                                 u=1  imp:n=1
12  66 -0.66675   21                                     u=1  imp:n=1
13  0            -31 34 -30 33 -35 32        lat=2 fill=1 u=2  imp:n=1
14  0            -1 4 -5 -52                       fill=2 u=3  imp:n=1
15  66 -0.66675  -22                                     u=4  imp:n=1
16  68 -2.23      22 -23                                 u=4  imp:n=1
17  66 -0.66675   23                                     u=4  imp:n=1
18  0            -41 44 -40 43 -45 42        lat=2 fill=4 u=5  imp:n=1
19  0            -1 4 -5  52                       fill=5 u=3  imp:n=1
20  62 -7.8       1:-4:5                                 u=3  imp:n=1
21  0            -2 3 -6                           fill=3 u=6  imp:n=1
c
22  64 -0.001293  51 -53 56 -57 60 -61 #21               u=6  imp:n=1
23  65 -7.8       (-51:53:-56:57:-60:61)                 u=6  imp:n=1
24  0             50 -54 55 -58 59 -62             fill=6      imp:n=1
c
c Slab tanks:
120 66 -1.3335   -122                                    u=10 imp:n=1
121 64 -0.001293  122                                    u=10 imp:n=1
123 0             121 -123 131 -132 135 -136     fill=10 u=11 imp:n=1
124 62 -7.8      -121:123:-131:132:-135:136              u=11 imp:n=1
125 0             120 -124 130 -133 134 -137     fill=11 u=12 imp:n=1
130 64 -0.001293  106 -107 111 -112 115 -116 #125        u=12 imp:n=1
131 65 -7.8       (-106:107:-111:112:-115:116)           u=12 imp:n=1
132 0             105 -108 110 -113 114 -117     fill=12      imp:n=1
140 like 132 but trcl (0 0 53.975)                            imp:n=1
c
c Tank 5E-7:
210 66 -1.3335   -252                                    u=21 imp:n=1
211 64 -0.001293  252                                    u=21 imp:n=1
212 0            -201 204 -205                   fill=21 u=22 imp:n=1
213 62 -7.8       201:-204:205                           u=22 imp:n=1
214 0            -202 203 -206                   fill=22 u=23 imp:n=1
215 64 -0.001293  251 -253 256 -257 260 -261 #214        u=23 imp:n=1
216 65 -7.8       (-251:253:-256:257:-260:261)           u=23 imp:n=1
217 0             250 -254 255 -258 259 -262     fill=23      imp:n=1
c
c Tank 5C-2:
310 66 -1.3335   -352                                    u=31 imp:n=1
311 64 -0.001293  352                                    u=31 imp:n=1
312 0            -301 304 -305                   fill=31 u=32 imp:n=1
313 62 -7.8       301:-304:305                           u=32 imp:n=1
314 0            -302 303 -306                   fill=32 u=33 imp:n=1
c
315 0            -310 312 -314                   fill=31 u=34 imp:n=1
316 62 -7.8       310:-312:314                           u=34 imp:n=1
317 0            -311 313 -315                   fill=34 u=33 imp:n=1
318 64 -0.001293  351 -353 356 -357 360 -361 #314 #317   u=33 imp:n=1
319 65 -7.8       (-351:353:-356:357:-360:361)           u=33 imp:n=1
320 0             350 -354 355 -358 359 -362     fill=33      imp:n=1
c
c Tank 5C-6A:
410 69 -7.4589   -452                                    u=41 imp:n=1
411 64 -0.001293  452                                    u=41 imp:n=1
412 0            -401 404 -405                   fill=41 u=42 imp:n=1
413 62 -7.8       401:-404:405                           u=42 imp:n=1
414 0            -402 403 -406                   fill=42 u=43 imp:n=1
415 64 -0.001293  451 -453 456 -457 460 -461 #414        u=43 imp:n=1
416 65 -7.8       (-451:453:-456:457:-460:461)           u=43 imp:n=1
417 0             450 -454 455 -458 459 -462     fill=43      imp:n=1
c
c Tank 5C-6B:
510 69 -7.4589   -552                                    u=51 imp:n=1
511 64 -0.001293  552                                    u=51 imp:n=1
512 0            -501 504 -505                   fill=51 u=52 imp:n=1
513 62 -7.8       501:-504:505                           u=52 imp:n=1
514 0            -502 503 -506                   fill=52 u=53 imp:n=1
515 64 -0.001293  551 -553 556 -557 560 -561 #514        u=53 imp:n=1
516 65 -7.8       (-551:553:-556:557:-560:561)           u=53 imp:n=1
517 0             550 -554 555 -558 559 -562     fill=53      imp:n=1
c
c Outside bin area:
101 63 -0.3      -900 100 -102
                  #24 #132 #140 #217 #320 #417 #517             imp:n=1
102 0            -900 102                                       imp:n=0
103 67 -2.35     -900 -100 101                                  imp:n=1
104 63 -1.0      -900 -101                                      imp:n=1
105 0             900                                           imp:n=0
c --------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
c --------------------------------------------------------------------
c *** Tank 5D-6 ***
1   cx   19.685
2   cx   20.32
3   px  -83.82
4   px  -83.185
5   px   83.185
6   px   83.82
c *** Tank 5D-6 Raschig rings ***
20  c/x  0 -4.861 1.190625
21  c/x  0 -4.861 1.825625
22  c/x  0  4.861 1.190625
23  c/x  0  4.861 1.825625
c *** Raschig ring lattice surfaces ***
30  p    0  0.5 0.8660254 -1.374
31  py   2.748
32  p    0 -0.5 0.8660254 -6.87
33  p    0  0.5 0.8660254 -6.87
34  py  -2.748
35  p    0 -0.5 0.8660254 -1.374
c
40  p    0  0.5 0.8660254  6.87
41  py   2.748
42  p    0 -0.5 0.8660254  1.374
43  p    0  0.5 0.8660254  1.374
44  py  -2.748
45  p    0 -0.5 0.8660254  6.87
c *** Tank 5D-6 Box ***
50  pz  -21.867
51  pz  -21.59
52  pz   0
53  pz   82.631
54  pz   82.908
c
55  px  -107.6325
56  px  -107.3555
57  px   107.3555
58  px   107.6325
c
59  py  -55.5625
60  py  -55.2855
61  py   55.2855
62  py   55.5625
c *** 5D-5A/B box ***
105 pz  -129.817
106 pz  -129.538
107 pz  -86.279
108 pz  -86.002
c
110 px -108.9025
111 px -108.6255
112 px  108.6255
113 px  108.9025
c
114 py -108.9025
115 py -108.6255
116 py  108.6255
117 py  108.9025
c *** Tank 5D-5A/B ***
120 pz  -107.9095
121 pz  -107.2745
122 pz  -104.0995
123 pz  -100.9245
124 pz  -100.2895
c
130 px  -76.835
131 px  -76.2
132 px   76.2
133 px   76.835
c
134 py  -76.835
135 py  -76.2
136 py   76.2
137 py   76.835
c *** Tank 5E-7 ***
201  c/x -65.3645 -14.882 5.4102
202  c/x -65.3645 -14.882 5.715
203  px  -69.05625
204  px  -68.75145
205  px   68.75145
206  px   69.05625
c *** Tank 5E-7 Box ***
250  pz  -21.867
251  pz  -21.59
252  pz  -14.882
253  pz   44.531
254  pz   44.808
c
255  px  -96.2025
256  px  -95.9255
257  px   95.9255
```

```
258  px   96.2025
c
259  py  -131.1275
260  py  -130.8505
261  py  -58.3795
262  py  -58.1025
c *** Tank 5C-2 top ***
301  c/x  66.7145 -13.255 6.40968
302  c/x  66.7145 -13.255 7.065
303  px  -107.95
304  px  -107.29468
305  px   107.95
306  px   107.9501
310  c/x  79.4945 -13.255 5.11302
311  c/x  79.4945 -13.255 5.715
312  px  -80.01
313  px  -79.40802
314  px   80.01
315  px   80.0101
c *** Tank 5C-2 Box ***
350  pz  -21.867
351  pz  -21.59
352  pz  -13.255
353  pz   44.531
354  pz   44.808
c
355  px  -126.6825
356  px  -126.4055
357  px   126.4055
358  px   126.6825
c
359  py   58.1025
360  py   58.3795
361  py   130.8505
362  py   131.1275
c *** Tank 5C-6A ***
401  c/x -126.642 -68.1815 13.0175
402  c/x -126.642 -68.1815 13.6525
403  px  -167.64
404  px  -167.005
405  px   167.005
406  px   167.64
c *** Tank 5C-6A Box ***
450  pz  -129.817
451  pz  -129.54
452  pz  -68.1815
453  pz  -53.259
454  pz  -52.982
c
455  px  -191.4525
456  px  -191.1755
457  px   191.1755
458  px   191.4525
c
459  py  -194.6275
460  py  -194.3505
461  py  -111.7195
462  py  -111.4425
c *** Tank 5C-6B ***
501  c/x  126.642 -68.1815 13.0175
502  c/x  126.642 -68.1815 13.6525
503  px  -167.64
504  px  -167.005
505  px   167.005
506  px   167.64
c *** Tank 5C-6B Box ***
550  pz  -129.817
551  pz  -129.54
552  pz  -68.1815
553  pz  -53.259
554  pz  -52.982
c
555  px  -191.4525
556  px  -191.1755
557  px   191.1755
558  px   191.4525
c
559  py   111.4425
560  py   111.7195
561  py   194.3505
562  py   194.6275
c ***reflection slab***
100 pz -139.977
101 pz -170.457
102 pz  204.7875
c ***world sphere***
900 so  350
c
c ---------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c Stainless Steel Pipe 304L (Si, Cr, Mn, Fe, Ni)
m62  14000.50c -0.01
     24000.50c -0.19
     25055.50c -0.02
     26000.55c -0.68
     28000.50c -0.10
c Water (H, O)
m63   1001.50c 0.666667
      8016.50c 0.333333
c Air (C, N, O, Ar) composition from Attix p. 523
m64   6000.50c -0.000124
      7014.50c -0.755267
      8016.50c -0.231781
     18000.35d -0.012828
c Carbon steel (C, Fe)
m65   6000.50c -0.005
     26000.55c -0.995
c Pu(NO3)4 Solution
m66   1001.50c 6.19542E-02
      7014.50c 2.01476E-03
      8016.50c 3.70214E-02
     94238.50c 2.17560E-06
     94239.55c 4.84386E-04
     94241.50c 1.45901E-05
     94242.50c 2.53764E-06
c Concrete (NBS Ordinary) from Harmon et. al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67   1001.50c -0.006
      8016.50c -0.5
     11023.50c -0.017
     13027.50c -0.048
     14000.50c -0.315
     19000.50c -0.019
     20000.50c -0.083
     26000.55c -0.012
c Raschig rings (nat. B assumed - 20% B-10)
m68   5010.50c 9.14626E-24
      5011.56c 3.68149E-23
      8016.50c 4.49308E-02
     11023.50c 2.39502E-03
     13027.50c 4.97719E-04
     14000.50c 1.80268E-02
c UO2(NO3)2*6H2O Solution
m69   1001.50c 4.60180E-01
      7014.50c 1.77197E-03
      8016.50c 2.37178E-01
     92235.50c 4.48373E-05
     92238.50c 8.41148E-04
c
mode n
print 40 60 80 100 110 126
kcode 1500 1. 20 120
ksrc 0    0    -104
     0    0     -50
     0   -2.0    -4.86
     0    0      -4.86
     0    2.0    -4.86
     0  -65.36  -17.58
     0   66.71  -16.75
     0   79.49  -16.21
     0 -126.60  -75
     0  126.60  -75
```

TOMB1

```
=CSAS25   PARM=SIZE=250000
TWO SLAB TANKS, TWO SILICA GEL BEDS, EVAP, EVAP COND, EVAP COND TANK-
TOMB1
'SIDES AND TOP OF BOXES REFLECTED BY CFT SNOW - .30 DENSITY
'HALF FULL SOURCE IN EACH TANK EXCEPT FULL IN SILICA GEL COLUMNS
'AND EXCEPT HALF DENSITY, FULL SOURCE IN 5D-6
'BOTTOM REFLECTED BY 3FT CONCRETE
'.001 H2O INSIDE BOXES
27GROUPNDF4  INFHOMMEDIUM
SOLNPU(NO3)4 1 200 0 1. 293 94238 0.43 94239 96.14 94241 2.92 94242
0.51 END
SOLNPU(NO3)4 10 200 0 .5 293 94238 0.43 94239 96.14 94241 2.92 94242
0.51 END
SOLNUO2(NO3)2 8 350 0 1. 293 92235 5. 92238 95.  END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  8 1.0 END
H2O  2 1.0 END
SS304 3 1.0 END
H2O  4 0.001 END
REG-CONCRETE  5  1.0  END
H2O  6 0.3 END
TI   9 1.0 END
'B-10  7 0 9.14626-4 END
'B-11  7 0 3.68149-3 END
O     7 0 4.49308-2 END
NA    7 0 2.39502-3 END
AL    7 0 4.97719-4 END
SI    7 0 1.80268-2 END
END COMP
TWO SLAB TANKS, TWO SILICA GEL BEDS, EVAP, EVAP COND, EVAP COND TANK-
TOMB1
READ PARM NB8=400 GEN=120 NPG=6000 NSK=20
TBA=4 NUB=YES TME=1000 PLT=NO END PARM

READ GEOM
```

```
  COM=" 2.50IN X 5FT X 5FT SLAB TANK - HALF FULL OF SOURCE"
UNIT 1
CUBOID   4  1 153.034   0.636   153.034   0.636   6.984  3.810
CUBOID   1  1 153.035   0.635   153.035   0.635   6.985   .635
CUBOID   3  1 153.670   0.  153.670   0.  7.62  0.

  COM="SUBSET OF ONE SLAB TANK BOX CONTAINING ONE UNIT 1 SLAB TANK"
UNIT 2
CUBOID   4  1 218.0819  0.2769  218.0819 0.2769  44.0919 0.2769
HOLE   1    38. 38. 22.
CUBOID   3  1 218.3588  0.  218.3588  0.  44.3688 0.

  COM=" 10.7532 CM DIA SPHERE FULL OF PU-239(96)NH"
'UNIT 40
'SPHERE   1  1  5.3766 ORIGIN  0.  0.  0.

  COM="1 7/16 OD X 15/16 ID PYREX PIPE"
UNIT 4
XCYLINDER  10 1 1.1906  167.0   0.00 ORIGIN  0. 0.
XCYLINDER   7 1 1.8256  167.0   0.00 ORIGIN  0. 0.

  COM="40.64CM OD X 167.64CM LG PU EVAP COND TANK FULL OF PU NITRATE"
UNIT 5
XCYLINDER  10 1 19.685 167.64  0.00 ORIGIN  0. 0.
HOLE 4 0 0 17.80
HOLE 4 0 0 12.00
HOLE 4 0 0 6.00
HOLE 4 0 0 0
HOLE 4 0 0 -6.00
HOLE 4 0 0 -12.00
HOLE 4 0 0 -17.80

HOLE 4 0 5.0 15.00
HOLE 4 0 5.0 9.00
HOLE 4 0 5.0 3
HOLE 4 0 5.0 -3
HOLE 4 0 5.0 -9.00
HOLE 4 0 5.0 -15.00

HOLE 4 0 -5.0 15.00
HOLE 4 0 -5.0 9.00
HOLE 4 0 -5.0 3.00
HOLE 4 0 -5.0 -3.00
HOLE 4 0 -5.0 -9.00
HOLE 4 0 -5.0 -15.00

HOLE 4 0 10. 12.00
HOLE 4 0 10. 6
HOLE 4 0 10. 0
HOLE 4 0 10. -6.00
HOLE 4 0 10. -12.00

HOLE 4 0 -10. 12.00
HOLE 4 0 -10. 6.00
HOLE 4 0 -10. 0.00
HOLE 4 0 -10. -6.00
HOLE 4 0 -10. -12.00

HOLE 4 0 15.0 9.00
HOLE 4 0 15.0 3
HOLE 4 0 15.0 -3
HOLE 4 0 15.0 -9.00

HOLE 4 0 -15.0 9.00
HOLE 4 0 -15.0 3
HOLE 4 0 -15.0 -3
HOLE 4 0 -15.0 -9.00

HOLE 4 0 17.6 0.00
HOLE 4 0 -17.6 0.00
XCYLINDER   3 1 20.32  167.64  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 5 - 5D-6"
UNIT 6
CUBOID   4  1 215.5419  0.2769  111.4019  0.2769  105.0519  0.2769
HOLE   5    28. 58. 23.
CUBOID   3  1 215.8188  0.  111.6788  0.  105.3288  0.

  COM="27.305 OD X 335.28 LG URANIUM SILICA GEL BED"
UNIT 7
XCYLINDER   8 1 13.0175  335.28 0.00 ORIGIN  0. 0.
XCYLINDER  3 1 13.6525  335.28  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 7 - 5C-6A"
UNIT 8
CUBOID   4  1 383.1819  0.2769  83.4619  0.2769  77.1119  0.2769
HOLE   7   28. 68. 60.84
CUBOID   3  1 383.4588  0.  83.7388  0.  77.3888 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 7 - 5C-6B"
UNIT 9
CUBOID   4  1 383.1819  0.2769  83.4619  0.2769  77.1119  0.2769
HOLE   7   28. 16. 60.84
CUBOID   3  1 383.4588  0.  83.7388  0.  77.3888 0.

  COM="14.13CM OD X 215.9CM LG PU PROD EVAP  - LARGE END - 5C-2"
UNIT 11
XHEMICYL-Z   1 1 6.4097  215.9   0.00 ORIGIN  0. 0.
XCYLINDER   9 1 7.065  215.9   0.00 ORIGIN  0. 0.

  COM="11.43CM OD X 160.02CM LG PU PROD EVAP  - SMALL END - 5C-2"
UNIT 12
XHEMICYL-Z   1 1 5.11302  160.02  0.00 ORIGIN  0. 0.
XCYLINDER   9 1 5.7150  160.02  0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 10 AND ONE UNIT 11 - 5C-2"
UNIT 13
CUBOID   4  1 253.6419  0.2769  73.3019  0.2769  67.2288  0.2769
HOLE   11  36.  8. 9.
HOLE   12  91. 21. 9.
CUBOID   3  1 253.9188  0.  73.5788  0.  67.2288  0.

  COM="11.43CM OD X 138.1125CM LG PU PROD EVAP CONDENSER"
UNIT 14
XHEMICYL-Z   1 1 5.4102  138.1125   0.00 ORIGIN  0. 0.
XCYLINDER   3 1 5.715  138.1125   0.00 ORIGIN  0. 0.

  COM="SUBSET OF ONE BOX CONTAINING ONE UNIT 14 - 5E-7"
UNIT 15
CUBOID   4  1 192.6819  0.2769 73.3019  0.2769  66.9519  0.2769
HOLE  14  26. 67. 7.
CUBOID   3  1 192.9588 0.  73.5788 0.  67.2288 0.


  COM="SLAB OF CONCRETE 3FT X 13.56FT X 13.56FT"
UNIT 17
CUBOID   5  1 413.38  0.  401.38  5.  91.44  0.

  COM="BENCHMARK- START SOURCE SPHERE"
UNIT 10
SPHERE 2 1 1.6  ORIGIN 0. 0. 0.

  COM="COLLECTION OF ALL SUBSETS INTO GLOBAL"
GLOBAL
UNIT 18
CUBOID   6  1  321.941  -91.441   309.941  -86.441 325.66 -91.441
HOLE   8  -80. -85.  10.16      COM="5C-6A"
HOLE   2   0. 0. 10.16       COM="5D-5A"
HOLE   2   0. 0. 63.821      COM="5D-5B"
HOLE   15   25. -17.  118.0  COM="5E-7"
HOLE   6   8. 58. 118.       COM="5D-6"
HOLE   13  -5. 170.0  118.0  COM="5C-2"
HOLE   9  -80. 221.  10.16      COM="5C-6B"
HOLE   17   -91.44  -91.44  -91.44   COM="CONCRETE"
'HOLE  10  116.  -17.5  70.5 COM="5C-6A"
'HOLE  10  116.   50.  121. COM="5E-7"
'HOLE  10  116.  116.   34. COM="5D-5A"
'HOLE  10  116.  116.   88. COM="5D-5B"
'HOLE  10  116.  116.   142. COM="5D-6"
'HOLE  10  136.  177.0  123. COM="5C-2"
'HOLE  10  161.  191.0  123. COM="5C-2"
'HOLE  10  116.  237.   70.  COM="5C-6B"


END GEOM
READ START NST=6
TFX=116. TFY=-17.5 TFZ=70.5 LNU=750
TFX=116. TFY=50.  TFZ=121. LNU=1500
TFX=116. TFY=116. TFZ=34. LNU=2250
TFX=116. TFY=116. TFZ=88. LNU=3000
TFX=116. TFY=116. TFZ=142. LNU=3750
TFX=136. TFY=177.0 TFZ=123. LNU=4500
TFX=161. TFY=191.0 TFZ=123. LNU=5250
TFX=116. TFY=237. TFZ=70. LNU=6000
END START
END DATA
END
```

15ADUAE

```
15ADUAE - PPC Tanks - Upper Level
c
c Cell cards
c
c ---------------------------------------------------------------------
c Slab tanks:
20  66 -1.3335   -1                                           u=1  imp:n=1
21  64 -0.001293  1                                           u=1  imp:n=1
23  0             21 -23 31 -32 35 -36             fill=1  u=2  imp:n=1
24  62 -7.8      -21:23:-31:32:-35:36                      u=2  imp:n=1
25  0             20 -24 30 -33 34 -37             fill=2  u=3  imp:n=1
30  64 -0.001293  6 -7 11 -12 15 -16 #25                    u=3  imp:n=1
31  65 -7.8      -6:7:-11:12:-15:16                        u=3  imp:n=1
32  0             5 -8 10 -13 14 -17               fill=3       imp:n=1
c
120 66 -1.3335   -1                                           u=10 imp:n=1
121 64 -0.001293  1                                           u=10 imp:n=1
123 0             121 -123 131 -132 135 -136      fill=10 u=11 imp:n=1
124 62 -7.8      -121:123:-131:132:-135:136                 u=11 imp:n=1
125 0             120 -124 130 -133 134 -137      fill=11 u=12 imp:n=1
130 64 -0.001293  106 -107 111 -112 115 -116 #125           u=12 imp:n=1
131 65 -7.8       (-106:107:-111:112:-115:116)              u=12 imp:n=1
132 0             105 -108 110 -113 114 -117      fill=12      imp:n=1
c
c Tank 5E-7:
210 66 -1.3335   -1                                           u=21 imp:n=1
211 64 -0.001293  1                                           u=21 imp:n=1
212 0            -201 204 -205                    fill=21 u=22 imp:n=1
213 62 -7.8       201:-204:205                              u=22 imp:n=1
214 0            -202 203 -206                    fill=22 u=23 imp:n=1
215 64 -0.001293  251 -253 256 -257 260 -261 #214           u=23 imp:n=1
```

```
216 65 -7.8       (-251:253:-256:257:-260:261)           u=23 imp:n=1
217 0              250 -254 255 -258 259 -262      fill=23      imp:n=1
c
c Tank 5C-2:
310 66 -1.3335   -1                                     u=31 imp:n=1
311 64 -0.001293  1                                     u=31 imp:n=1
312 0            -301 304 -305                  fill=31 u=32 imp:n=1
313 62 -7.8       301:-304:305                          u=32 imp:n=1
314 0            -302 303 -306                  fill=32 u=33 imp:n=1
c
315 0            -310 312 -314                  fill=31 u=34 imp:n=1
316 62 -7.8       310:-312:314                          u=34 imp:n=1
317 0            -311 313 -315                  fill=34 u=33 imp:n=1
318 64 -0.001293  351 -353 356 -357 360 -361 #314 #317    u=33 imp:n=1
319 65 -7.8      -351:353:-356:357:-360:361             u=33 imp:n=1
320 0             350 -354 355 -358 359 -362      fill=33      imp:n=1
c
c Tank 5C-6A:
410 69 -7.4589   -1                                     u=41 imp:n=1
411 69 -7.4589    1                                     u=41 imp:n=1
412 0            -401 404 -405                  fill=41 u=42 imp:n=1
413 62 -7.8       401:-404:405                          u=42 imp:n=1
414 0            -402 403 -406                  fill=42 u=43 imp:n=1
415 64 -0.001293  451 -453 456 -457 460 -461 #414       u=43 imp:n=1
416 65 -7.8      -451:453:-456:457:-460:461             u=43 imp:n=1
417 0             450 -454 455 -458 459 -462      fill=43      imp:n=1
418 like 417 but trcl (-85 0 0)                              imp:n=1
c
c Tank 5D-6:
510 66 -0.5334   -501 504 -505                          u=51 imp:n=1
511 62 -7.8       501:-504:505                          u=51 imp:n=1
512 0            -502 503 -506                  fill=51 u=52 imp:n=1
513 64 -0.001293  551 -553 556 -557 560 -561 #512       u=52 imp:n=1
514 65 -7.8      -551:553:-556:557:-560:561             u=52 imp:n=1
515 0             550 -554 555 -558 559 -562      fill=52      imp:n=1
c
c Outside bin area:
101 63 -0.3    -900 100 -102 #32 #132 #217 #320 #417 #418 #515 imp:n=1
102 0            -900 102                                    imp:n=0
103 67 -2.35     -900 -100 101                               imp:n=1
104 63 -1.0      -900 -101                                   imp:n=1
105 0             900                                        imp:n=0
c -----------------------------------------------------------------------
c
c Note: next line must be completely blank

c Surface cards
c -----------------------------------------------------------------------
1   pz  32.027
c *** 5D-5A box ***
5   pz  10.16
6   pz  10.437
7   pz  53.698
8   pz  53.975
c
10  px -108.9025
11  px -108.6255
12  px  108.6255
13  px  108.9025
c
14  py -218.805
15  py -218.528
16  py -1.277
17  py -1.0
c *** 5D-5A tank ***
20  pz  28.217
21  pz  28.852
23  pz  35.202
24  pz  35.837
c
30  px -46.0445
31  px -45.4095
32  px  106.9905
33  px  107.6255
c
34  py -217.528
35  py -216.893
36  py -64.493
37  py -63.858
c
c *** 5D-5B box ***
105 pz  10.16
106 pz  10.437
107 pz  53.698
108 pz  53.975
c
110 px -108.9025
111 px -108.6255
112 px  108.6255
113 px  108.9025
c
114 py  1.0
115 py  1.277
116 py  218.528
117 py  218.805
c *** 5D-5B tank ***
120 pz  28.217
121 pz  28.852
123 pz  35.202
124 pz  35.837
c
130 px -107.6255
131 px -106.9905
132 px  45.4095
133 px  46.0445
c
134 py  63.858
135 py  64.493
136 py  216.893
137 py  217.588
c
c *** Tank 5E-7 ***
201 c/x -226.797 32.027 5.11302
202 c/x -226.797 32.027 5.715
203 px  -30.487
204 px  -30.1822
205 px   107.3207
206 px   107.6255
c *** Tank 5E-7 Box ***
250 pz   10.16
251 pz   10.437
253 pz   76.558
254 pz   76.835
c
255 px  -83.5025
256 px  -83.2255
257 px   108.6255
258 px   108.9025
c
259 py  -292.83
260 py  -292.553
261 py  -220.082
262 py  -219.805
c
c *** Tank 5C-2 top ***
301 c/y  118.5145 32.027 6.410
302 c/y  118.5145 32.027 7.065
303 py  -217.528
304 py  -216.873
305 py  -2.283
306 py  -1.628
310 c/y  131.295 32.027 5.113
311 c/y  131.295 32.027 5.715
312 py  -217.528
313 py  -217.251
314 py  -57.785
315 py  -57.508
c *** Tank 5C-2 Box ***
350 pz   10.16
351 pz   10.437
353 pz   76.558
354 pz   76.835
c
355 px   109.9025
356 px   110.1795
357 px   182.6505
358 px   182.9275
c
359 py  -218.805
360 py  -218.528
361 py   34.283
362 py   34.56
c
c *** Tank 5C-6A ***
401 c/y -124.832 32.027 13.0175
402 c/y -124.832 32.027 13.6525
403 py  -118.604
404 py  -216.893
405 py   215.406
406 py   216.041
c *** Tank 5C-6A Box ***
450 pz   10.16
451 pz   10.437
453 pz   86.718
454 pz   86.995
c
455 px  -193.0875
456 px  -192.8105
457 px  -110.1795
458 px  -109.9025
c
459 py  -165.317
460 py  -165.04
461 py   217.311
462 py   217.588
c
c *** Tank 5D-6 ***
501 c/x  241.402 32.027 19.685
502 c/x  241.402 32.027 20.32
503 px  -107.6255
504 px  -106.9905
505 px   59.3795
506 px   60.0145
c *** Tank 5D-6 Box ***
550 pz   10.16
551 pz   10.437
553 pz   114.658
554 pz   114.935
c
555 px  -108.9025
556 px  -108.6255
557 px   106.0855
558 px   106.3625
c
```

```
559 py   219.805
560 py   220.082
561 py   330.653
562 py   330.930
c
c ***Reflection Slab***
100 pz  0
101 pz -30.48
102 pz  236.855
c ***world sphere***
900 so  400
c
c ----------------------------------------------------------------------
c
c Note: next line must be completely blank

c Data cards
c
c Materials
c
c Stainless Steel Pipe 304L (Si, Cr, Mn, Fe, Ni)
m62  14000.50c -0.01
     24000.50c -0.19
     25055.50c -0.02
     26000.55c -0.68
     28000.50c -0.10
c Water (H, O)
m63   1001.50c 0.666667
      8016.50c 0.333333
c Air (C, N, O, Ar) composition from Attix p. 523
m64   6000.50c -0.000124
      7014.50c -0.755267
      8016.50c -0.231781
     18000.35d -0.012828
c Carbon steel (C, Fe)
m65   6000.50c -0.005
     26000.55c -0.995
c Pu(NO3)4 Solution
m66   1001.50c 6.19542E-02
      7014.50c 2.01476E-03
      8016.50c 3.70214E-02
     94238.50c 2.17560E-06
     94239.55c 4.84386E-04
     94241.50c 1.45901E-05
     94242.50c 2.53764E-06
c Concrete (NBS Ordinary) from Harmon et. al. Criticality Calculation
c with MCNP. A Primer. p. C-5 (Elements: H, O, Na, Si, Al, Ca, Fe, K
c adjusted to sum to unity without minor trace elements)
m67   1001.50c -0.006
      8016.50c -0.5
     11023.50c -0.017
     13027.50c -0.048
     14000.50c -0.315
     19000.50c -0.019
     20000.50c -0.083
     26000.55c -0.012
c Raschig rings (nat. B assumed - 20% B-10)
m68   5010.50c 9.14626E-04
      5011.56c 3.68149E-03
      8016.50c 4.49308E-02
     11023.50c 2.39502E-03
     13027.50c 4.97719E-04
     14000.50c 1.80268E-02
c UO2(NO3)2*6H2O Solution
m69   1001.50c 4.60180E-01
      7014.50c 1.77197E-03
      8016.50c 2.37178E-01
     92235.50c 4.48373E-05
     92238.50c 8.41148E-04
c
mode n
print 40 60 80 100 110 126
kcode 1500 1. 20 120
ksrc  30   -140   30
     -30    140   30
      46   -227   30
      118  -109   30
      131  -109   30
     -125   0     30
     -210   0     30
     -25    241   30
```